Assessing Drilling Waste Disposal Areas: Compliance Options for Reclamation Certification

February 2005

ONGOING COMMITMENT

Alberta Environment is committed to working with the Energy and Utilities Board, Sustainable Resource Development, and industry to ensure that guidance for drilling waste management and environmental endpoints are harmonized and drilling waste disposal areas pose no risk to the environment.

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http://www3.gov.ab.ca/env/protenf/landrec/upstream/index.html

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OVERVIEW

Alberta's certification program for reclaimed upstream oil and gas facilities changed on October 1, 2003 to include stronger requirements for management of contamination, including any related to drilling waste. This document was developed by representatives from the Canadian Association of Petroleum Producers, drilling waste disposal consultants, Sustainable Resource Development, the Energy and Utilities Board, and Alberta Environment to provide guidance for assessing drilling waste disposal areas for reclamation.

To address the diversity of drilling wastes and available information types, three compliance options have been developed. All three options are intended to deliver the same environmental results, which are based mainly on the Alberta Energy and Utilities Board 1996 Guide 50: Drilling Waste Management. Each of the three options is discussed in this document and appendices are included to support technical procedures included in the options. Compliance Options One and Two exempt drilling waste disposal areas from a Phase 2 environmental site assessment (ESA). If the drilling waste disposal area does not meet the requirements specified in either of these options, a Phase 2 ESA (Compliance Option 3) must be conducted in the drilling waste disposal area.

A. BACKGROUND

1. Introduction

Drilling waste disposal has been regulated in Alberta since 1975, when the Energy Resources Conservation Board (ERCB) released the Interim Directive *ID-OG-75-2*. Interim Directive (ID) 93-1 and *Guide 50: Drilling Waste Management* superseded this document in June 1993. Then in 1996 the Alberta Energy and Utilities Board (EUB) issued a revision to *Guide 50*, which was introduced with *Information Letter (IL) 96-13: Revision of Guide 50 Drilling Waste Management*.

Under the Upstream Oil and Gas Reclamation and Remediation Program, which came into effect on October 1, 2003, oil and gas operators are required to submit drilling waste disposal information for drilling waste that was disposed of on a wellsite or at a remote sump or land treatment site to indicate compliance with Alberta Environment standards. Acknowledging that soil quality guidelines have changed significantly since 1975, this guideline harmonizes Alberta Environment requirements for drilling waste disposal areas with the 1996 *Guide 50* whenever possible.

This guideline supersedes the Fact Sheet, R&R/04-1, *Assessing Drilling Waste Disposal Areas*, effective immediately.

2. Phased Environmental Site Assessments

This guidance document describes Phase 1 ESA processes under Compliance Options One and Two, and Phase 2 ESA requirements in Compliance Option Three. Uncertainty is inherent in any Phase 1 ESA. The Canadian Standards Association states that since a Phase 1 does not involve sample collection or other intrusive investigations, "a Phase 1 ESA report can, in most cases, only describe the likelihood of contamination being present or absent at a property" (CSA 1994). A Phase 1 ESA that is performed under the requirements of the CSA Phase 1 ESA Standard will reduce, but not eliminate uncertainty as to the potential for contamination to be present at a site. "Where this potential has been identified, the further reduction or elimination of uncertainty requires the performance of a Phase 2 ESA" (CSA 1994).

For drilling waste disposal areas, an advanced Phase 1 ESA as described in Compliance Options One and Two can form the basis for additional investigation of a site through a Phase 2 ESA. If there is insufficient information to complete a Phase 1 ESA, uncertainty will not be reduced and a Phase 2 ESA is required.

A Phase 2 ESA can be used to confirm or refute the potential contamination identified in a Phase 1 ESA, provide supplemental information for previous Phase 2 ESAs and provide the basis for evaluating site remediation needs. A Phase 2 ESA "characterization may range from a simple identification to a full delineation of the contamination on site" (CSA 2000). The Standard developed by the CSA establishes the fundamentals and practices for a Phase 2 ESA. The Standard provides a consistent framework and establishes "minimum requirements for conducting Phase 2 ESAs that can accommodate broader regulatory and liability requirements, as well as address pertinent site-specific requirements" (CSA 2000). The framework includes development of a sampling plan, preparation for and execution of an investigation that includes sampling and measuring, followed by interpretation and reporting on the information obtained.

3. Intent of Document

The intent of this document is to provide information and guidance on each of the three Compliance Options for drilling waste disposal areas to assist well licencees and reclamation practitioners in meeting Alberta Environment's requirements for the Upstream Oil and Gas Reclamation and Remediation Program. Where site audits or future events identify parameters that exceed Alberta Environment's remediation requirements, the licensee remains responsible for remediation, regardless of the results obtained from the checklists and calculations in this document.

4. Qualified People

The assessor should be objective and possess an appropriate combination of formal education, knowledge, skills and experience to conduct a technically sound assessment of the daily drilling records, Tour Reports, *Notification of Drilling Waste Disposal* form and to conduct a Phase 2 environmental site assessment (ESA), if required.

5. Reclamation of Drilling Waste Disposal Areas

The *Environmental Protection and Enhancement Act* (EPEA) requires an operator to conserve and reclaim specified land and obtain a reclamation certificate. The Conservation and Reclamation Regulation and EPEA definition of specified land includes land that is being or has been used or held for or in connection with the construction, operation or reclamation of a well, battery, oil production site, and pipeline. Land that has been used for a remote sump or land treatment is specified land.

Under the Upstream Oil and Gas Reclamation and Remediation Program, which came into effect on October 1, 2003, oil and gas operators are required to submit drilling waste disposal data for drilling waste that was disposed within a lease or at a remote sump or land treatment area.

(a) Drilling Waste Disposal Areas

Drilling waste disposal areas include portions of the wellsite, remote sump, or land treatment area where drilling wastes have been buried, spread on land, or mixed into soil. Off lease agricultural or forested land used for disposal of drilling waste by pump-off, landspray while drilling, or landspray does not require a reclamation certificate.

The *Phase 1 Environmental Site Assessment Guideline for Upstream Oil and Gas Sites* (AENV, 2001) outlines Alberta Environment's requirements for Phase 1 ESA level of effort. Occasionally, the location of remote sumps and off-site land treatment areas cannot be verified by file information. When this is the case, the assessor must be able to confirm that all the requirements of the above Phase 1 Guideline were met before declaring that the disposal location is unknown.

(b) Drilling Waste Disposal Methods

Guide 50 restricts drilling waste being managed by landspreading or mix bury cover to the wellsite or associated remote sump. Off-lease disposal options are landspraying, pump-off (clear liquids only) and landspraying while drilling (LWD). Land treatment of hydrocarbon-based or contaminated drilling waste may occur on or off the wellsite. Land treatment disposals and alternative disposal methods such as biopiles require approval from the EUB.

(c) Single and Multi-well Sumps

Single well remote sumps must be reclaimed prior to or at the time when the associated wellsite is reclaimed. Multi-well remote sumps should be reclaimed with one of the wells that generated the waste, or be reclaimed independently. If a well licensee chooses to associate a multi-well remote sump with a different well than the one currently being reclaimed, they must specify which well license, including legal land description, will include the remote sump in the *Reclamation Certificate Application* form and in the comments section of the Checklist. Land treatment areas must be reclaimed when the treatment activity is complete.

(d) Drilling Fluid Systems

Drilling fluid systems typically consist of bentonite and a range of additives mixed with water or hydrocarbon. The additives affect drilling waste characteristics such as pH, salinity, and toxicity that must be properly managed to prevent adverse environmental effects. Common water based systems include relatively low salinity gel chem muds and higher salinity advanced gel chem and salt systems. Advanced gel chem systems such as *potassium sulphate, potassium silicate, sodium silicate, or potassium formate* systems have potentially high salinity associated with them. Advanced gel chem systems are defined in the EUB *Information Letter (IL) 2001-3: Management of Drilling Wastes Associated with Advanced Gel Chemical Systems*. Hydrocarbon-based systems such as invert diesel systems have high concentrations of hydrocarbons that must be managed by land treatment or an alternative disposal method as per *Guide 50* or at an approved facility subject to waste tracking, characterization, and classification requirements under *Guide 58: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*, and subsequent updates to it.

A number of drilling fluid additives are used to ensure the fluid properties are compatible with the geological conditions encountered during drilling. Some additives are known to be toxic and some additives contain elevated levels of trace metals. Additional information on additives is provided within the description of each Compliance Option.

6. Compliance Options

(a) Compliance Option One

Compliance Option One requires submission of a *Notification of Drilling Waste Disposal Form* from *Guide 50*, or equivalent, and the Compliance Option One Checklist (with the attached Calculation Tables, if necessary) confirming that all *Guide 50* requirements were met. Compliance Option One will not be accepted for advanced gel-chem systems as defined in EUB *Information Letter IL 2001-3* (e.g., *potassium sulphate, potassium silicate, sodium silicate, or potassium formate)* unless an EUB written approval for the disposal and documentation proving compliance with the approval conditions are submitted. If insufficient information is available to allow completion of the Compliance Option One checklist, Compliance Option Two or a Phase 2 ESA must be completed.

(b) Compliance Option Two

Compliance Option Two requires submission of the completed Compliance Option Two Checklist and Calculation Tables (attached) confirming that the specified requirements have been met. This option may be used when a *Guide 50 Notification of Drilling Waste Disposal* form is incomplete or not available, and/or an advanced gel chemical drilling fluid system was used and disposed of on-site. If no information or insufficient information is available to allow

completion of either a Compliance Option One or Option Two checklist, a Phase 2 ESA must be completed.

(c) Compliance Option Three

A Phase 2 ESA of the drilling waste disposal area must be conducted if the Compliance Option One or Two Checklists cannot be completed due to insufficient information or if the available information indicates the waste does not meet the requirements for Compliance Option One or Compliance Option Two.

Each of the Compliance Options is discussed in more detail on the following pages.

B. COMPLIANCE OPTION ONE

Compliance Option One requires submission of a completed *Notification of Drilling Waste Disposal Form* from *Guide 50*, or equivalent, and the completed Compliance Option One Checklist (attached) confirming that all *Guide 50* requirements were met. If the Checklist results indicate the Calculation Tables are required, the completed tables must also be submitted.

Compliance Option One will not be accepted for advanced gel-chemical systems as defined in EUB Information Letter IL 2001-3 (e.g., *potassium sulphate, potassium silicate, sodium silicate, or potassium formate)* unless an EUB written approval for the disposal and documentation proving compliance with the approval conditions is available.

Compliance Option One applies also to landtreatment drilling waste disposal, alternative disposals such as biopiles, and disposal at an approved facility. If landtreatment or an alternative disposal method was used, the licensee must ensure that all conditions of the approval, as well as the requirements in *Guide 50* for the detailed disposal plan were met. If drilling waste was disposed at an approved waste management facility, information to verify that the waste was received at the facility must be available (e.g., invoice from the receiving facility, manifests, truck tickets, Alberta Oilfield Waste Form, or other documentation from the well file that would identify use of an approved waste management facility) must be listed as Reference Documents on the checklist. Reference documents must be submitted to Alberta Environment, if requested. If the well licensee does not have documentation confirming waste disposition, a Phase 2 ESA is required.

The Checklist and Calculation Tables will indicate if Compliance Option One is acceptable for a site or whether Compliance Option Two or a Phase 2 ESA is necessary. If the Compliance Option One Checklist cannot be completed because of insufficient information, the assessor must use Compliance Option Two or Three.

Background information is provided below to guide the completion of the Compliance Option One checklist.

1. General Disposal and Drilling Fluid Information

For Compliance Option One, a completed *Guide 50 Notification of Drilling Waste Disposal* form, or equivalent, must be reviewed using the Compliance Option One Checklist to ensure that the drilling waste disposal and drilling fluid systems were compliant with *Guide 50*.

If the cuttings associated with landspray or landspray-while-drilling were managed on the wellsite, these will often not have separate analytical information or a unique notification. The comments section of the *Notification of Drilling Waste Disposal Form* may indicate that a small volume of cuttings was mix-bury-covered or landspread on the wellsite. A separate *Notification of Drilling Waste Disposal Form* should have been completed and submitted, unless the wastes were disposed by landspray-while-drilling. If the total volume of cuttings is >50m^3 and no supporting disposal information is available, Compliance Option Two or Three is required. A calculation is provided in the checklist for estimating the volume of cuttings if the volume is not known.

Advanced gel chemical systems such as *potassium sulphate, potassium silicate, sodium silicate, or potassium formate* systems have potentially high salinity associated with them and therefore calculations (as outlined in Compliance Option Two) must be performed or a Phase 2 ESA conducted. Alternatively, post-disposal sampling results from a program conducted in

compliance with an EUB approval is acceptable if the results indicate compliance with the salinity, hydrocarbon, and trace element guidelines specified in Compliance Option Three.

A number of drilling fluid additives are used to ensure the fluid properties are compatible with the geological conditions encountered during drilling. Some additives are known to be toxic and some additives contained elevated levels of trace metals. The *Notification of Drilling Waste Disposal* form should provide a list of all additives used in the drilling fluid system. If this information is not included in the *Notification of Drilling Waste Disposal* form then an additional mud/additive list must be referenced. The additives used in the drilling process must be identified and described (e.g chrome-free lignosulfonate, aldehyde-based bactericide, etc.) so that potential toxicity and trace metal exceedances can be evaluated.

For mix-bury-cover disposal, the *Notification of Drilling Waste Disposal Form* must indicate the calculated post-disposal chloride concentration. *Guide 50* allowed up to 2000 mg/kg of chlorides with a loading limit of 1600 kg/site. This chloride concentration is incompatible with the *Guide 50 Equivalent Salinity Guidelines* (provided below) and will not be accepted by Alberta Environment because the *Guide 50* value will not achieve equivalent land capability requirements for reclamation. If the post disposal chloride concentration entered on the Notification Form exceeds 800 mg/kg, a Phase 2 ESA is required.

2. Hydrocarbon & Toxicity Management

Guide 50 requires testing of the waste for hydrocarbons if a hydrocarbon-based drilling fluid was used, hydrocarbons were added to the fluid, or the well was a horizontal oil well. For wastes generated under these conditions, hydrocarbon test results must be listed on the *Notification of Drilling Waste Disposal* form. Hydrocarbon test results will not be required for other drilling wastes that failed the original Microtox test but passed the Microtox test after charcoal filtration. Hydrocarbon concentrations in the final soil-waste mix must not exceed the *Guide 50* requirement of 0.1% (dry weight basis) for land treatment on subsoil, landspreading, and mix-bury-cover or 0.5% (dry weight basis) for land treatment on topsoil. Laboratories may provide the wet weight hydrocarbon values on the analytical back-up data results but the calculations on the *Notification of Drilling Waste Disposal* form require the dry weight value. Wet weight values can be converted to dry weight using the moisture content of the drilling waste sample.

Additives that may have toxicity concerns include bactericides, corrosion inhibitors, defoamers, emulsifiers and de-emulsifiers, foaming agents, lubricants, polymer stabilizers and breakers, surfactants, and shale control inhibitors. *Guide 50* required Microtox testing when an additive was used in a concentration that exceeded the toxicity threshold. Information on the toxicity of additives is available from the Petroleum Services Association of Canada (http://www.psac.ca).

3. Metals (Trace Elements) Management

Drilling fluid additives may contain trace metals and, depending on the quantities used, the drilling waste disposal area may exceed the *Canadian Environmental Quality Guidelines* for agricultural land use (CCME 1999 as updated). Metal sources of concern include, but are not limited to, the following:

- Zinc carbonate ($ZnCO_3$) is commonly used to remove H_2S if it is encountered during drilling. In some cases, $ZnCO_3$ is contaminated with cadmium. If the checklist indicates that a Phase 2 ESA sampling program is required to assess zinc concentrations, cadmium must also be measured.

- Barite ($BaSO_4$) is used to increase fluid density.

- Chrome lignosulphonates were commonly used as thinners at one time, but have been largely phased out.

Calculation Tables are provided for the most common metal additives. If any of these additives were used, the appropriate Calculation Table must be used to evaluate the need for a Phase 2 ESA. If other trace metals specified in *Guide 50* were added to the drilling fluid in excess of the *Guide 50* analysis thresholds, analytical data and the application rate (land treatment, landspreading, landspraying and landspray-while-drilling) or the maximum applied quantity (mix-bury-cover) must be available. If the information is not available or the application rate or maximum applied quantity exceed *Guide 50* requirements, a Phase 2 ESA must be conducted.

Compliance Option 1 - Drilling Waste Disposal Assessment Checklist

If any response to the checklist questions leads to a Phase 2 ESA requirement, an environmental site assessment must be conducted in accordance with Compliance Option Three. If insufficient information is available to allow completion of the Compliance Option One checklist, Compliance Option Two or a Phase 2 ESA must be completed.

1. General Disposal and Drilling Fluid Information:
If some or all of the drilling waste was managed on-site (on the wellsite) or at a landtreatment area or a remote sump, then the checklist must be completed. In some cases, the drilling waste may have been managed at a remote sump/site that is not tied to the wellsite and as such a separate reclamation certificate may have been or need to be applied for at that separate location. If the remote sump or land treatment area is tied to the wellsite, proceed with the checklist for the remote sump or land treatment area.

The checklist does not need to be completed for wastes disposed of by the following methods:

a) If drilling waste was managed at an EUB or AENV approved waste management facility, indicate this using the appropriate checkbox below and list the supporting documentation (e.g. waste manifests, truck tickets, invoices, Alberta Oilfield Waste Management Form) under Reference Documents.

b) If the waste was disposed at an off-site location by landspraying or landspray-while-drilling (LWD) and the *Notification of Drilling Waste Disposal* form indicates the disposal method and location.

The notification form will indicate the type of drilling fluid system used. Water-based drilling fluids can be described in numerous ways for example; gel chem, floc water, fresh water gel, gypsum water, nitrate gypsum water, etc.

1.0 Well Information: Unique Identifier (UI) _____
Spud Date _____
Well Depth _____

1.1 Disposal Method (Check all that apply):

On-site
- ☐ Mix-bury-cover
- ☐ Landspread
- ☐ Land Treatment

Remote Site
- ☐ Mix-bury-cover
- ☐ Landspread
- ☐ Land Treament

Off-site
- ☐ Landspray-while-drilling
- ☐ Landspray
- ☐ Pumpoff
- ☐ Disposal on Licence of Occupation (Public Land only)

☐ Land Fill/Waste Management Facility

☐ Other, specify: _____

	Yes	No
1.2 Was a remote site used?	☐	☐
If, Yes, is the remote site included in this reclamation application?	☐	☐
If not included, is the remote site a multi-well disposal location?	☐ In Comments section, indicate which well the remote site will be tied to for the purposes of reclamation	☐ Single well remote disposal site must be included with reclamation certificate application, unless it already has received a Reclamation Certificate.
1.3 Were water-based drilling fluids used (gel chemical drilling fluid system)?	☐	☐
If Yes, were all or part of the wastes disposed of on-site?	☐	☐
1.4 Were cuttings or solids disposed of on-site that were associated with off-site waste disposed by LWD or landspraying?	☐	☐
If Yes, is separate analytical information or unique notification available?	☐	☐
If separate information or notification is not available, is information available to show that the volume of waste disposed of on-site was 50 m^3 or less?	☐	☐
If the volume of waste disposed of on-site is unknown, is the estimated volume of waste disposed on site 50 m^3 or less? Volume of cuttings or solids disposed of on-site may be estimated by: $V_C = V_T - V_{OFF}$ Where: V_C = Volume of cuttings or solids (m^3) V_{OFF} = Volume of waste disposed of off-site V_T = Total volume of waste (m^3) and: $V_T = \left(\frac{WDm}{2000}\right)^2 \times 3.14 \times WDp \times 1.2$ Where: WDm = Well diameter (mm) WDp = Well Depth (m)	☐ Enter data below: V_C = _____ (m) V_T = _____ (m) V_{OFF} = _____ (m^3) WDm = _____ (mm) WDp = _____ (m)	☐ Phase 2 required

	Yes	No
1.5 Was the drilling fluid described as an advanced gel chemical system such as the following: *potassium sulphate, potassium silicate, sodium silicate, or potassium formate*?	☐	☐
If Yes, were all or part of the wastes disposed of on-site?	☐	☐
If wastes were disposed of on-site, was the disposal done in compliance with an approval from the EUB?	☐ Approval and post-disposal sampling results must be retained on file and provide to Alberta Environment upon request.	☐ Compliance Option Two or Three Required
1.6 Is a mud list available and can all the additives on the mud list be identified and described? Record the additives and their description (e.g., chrome-free lignosulfonate, aldehyde-based bactericide) on the attached form.	☐	☐ Phase 2 required
1.7 For mix-bury-cover disposal, was calculated or measured post-disposal chloride concentration 800 mg/kg or less?	☐	☐ Phase 2 required

2. Hydrocarbon & Toxicity Management

If hydrocarbon based drilling fluids were used (i.e. diesel inverts, synthetic or mineral oil systems) or hydrocarbons were added to the drilling fluid or the well is an horizontal oil well then it must be demonstrated that the resulting drilling waste was handled appropriately as per *Guide 50* or *Guide 58*. In most cases, if hydrocarbons were added to the system or if the well was a horizontal oil well it is still possible to dispose of the resulting drilling waste on the location and remain within allowable disposal limits but hydrocarbon testing and toxicity testing must have been conducted and documented on the notification form.

	Yes	No
2.1 Were hydrocarbon-based drilling fluids used or were hydrocarbons added to the drilling fluid or was the well a horizontal oil well?	☐	☐
If Yes, is documentation available showing that the wastes were disposed of in a manner consistent with *Guide 50* (1996) or *Guide 58*?	☐	☐ Phase 2 required

	Yes	No
2.2 If hydrocarbon was present, is the predicted post-disposal hydrocarbon concentration at or below the appropriate guideline? (subsoil: 0.1%, topsoil: 0.5%)?	☐	☐ Phase 2 required
2.3 Was a Microtox test required as indicated on the disposal notification form?	☐	☐
If Yes, did the waste pass the Microtox requirements as outlined in *Guide 50* (waste must pass either the original or charcoal Microtox)?	☐	☐ Phase 2 required
2.4 If the waste failed the Microtox test (i.e., Microtox EC50 (15) original and Microtox EC50 (15) charcoal treated, reading at 15 minutes < 75%) is there evidence that demonstrates the waste was treated to remove toxicity and retested or disposed of as per *Guide 58* (i.e., appropriately approved waste management facility)?	☐	☐ Phase 2 required

3. Metals (Trace Elements) Management

Some drilling fluids contain trace metals and other toxic compounds. Metal-containing additives that have been or are being used include barite ($BaSO_4$), zinc carbonate ($ZnCO_3$), and chrome-based thinners. If metal-based additives were used, the attached calculation tables must be completed and the results used to determine if a Phase 2 ESA is required.

	Yes	No
3.1 Was barite added to the drilling fluid?	☐	☐
If Yes, did it meet the requirements specified in the attached metal calculation table?	☐ Show calculation on attached form	☐ Phase 2 required
3.2 Was zinc carbonate added to the drilling fluid?	☐	☐
If Yes, did it meet the requirements specified in the attached metal calculation table?	☐ Show calculation on attached form	☐ Phase 2 required (Cadmium analysis will also be required.)
3.3 Were chrome-based thinners added to the drilling fluid?	☐	☐
If Yes, did it meet the requirements specified in the attached metal calculation table?	☐ Show calculation on attached form	☐ Phase 2 required

	Yes	No
3.4 Were any other metals added that triggered testing required by Guide 50?	☐	☐
If Yes, are waste analytical data and application rates (land treatment, landspreading, landspraying, landspray-while-drilling) or maximum application (mix-bury-cover) available?	☐	☐ Phase 2 required
If above data is available, did the application rate or maximum application meet *Guide 50* requirements?	☐	☐ Phase 2 required

Mud Additives (Attach additional pages if necessary.)

Product Name	Amount Used (units)	Brief Description of Product

Reference Documents (List all source documents used in the completion of this checklist. Attach additional pages if necessary. Documents must be supplied to Alberta Environment, if requested.)

Comments (Please provide any additional comments relevant to the decision process within the checklist. Attach additional pages if necessary.)

C. COMPLIANCE OPTION TWO

Compliance Option Two requires submission of the completed Compliance Option Two Checklist and accompanying Calculation Tables (attached) confirming that the specified requirements have been met. This option may be used when a *Guide 50 Notification of Drilling Waste Disposal* form is incomplete or not available, and/or an advanced gel chemical drilling fluid system was used and disposed on-site.

The Checklist and Calculation Tables will indicate if Compliance Option Two is acceptable for a site or whether a Phase 2 ESA is necessary. If no information or insufficient information is available to allow completion of either a Compliance Option One or Option Two checklist, a Phase 2 ESA must be completed where the waste disposal occurred. If the checklist indicates that a Phase 2 ESA is required and the disposal location is unknown, the Phase 2 ESA must be undertaken on the wellsite.

Background information is provided below to guide the completion of the Compliance Option Two checklist.

1. General Disposal and Drilling Fluid Information

There are various sources of information pertaining to the drilling activities on-site, including Tour Reports, daily drilling records, well files, contractor invoices and other information sources. The *Guide 50 Notification of Drilling Waste Disposal* form may be used to find information relating to the drilling waste disposal and drilling fluid systems.

The records review may indicate the type of drilling fluids used (e.g., gel chem, advanced gel chem, salt, or hydrocarbon-based systems). If the type of mud system cannot be determined, a Phase 2 ESA is required. The records review must identify and describe the additives that were added to the drilling fluid system, and quantity (i.e., number of sacks or pails) of each additive. If the well licensee cannot identify and describe the additives and the quantity used, a Phase 2 ESA is required.

If an advanced gel chem or salt- or hydrocarbon-based system was used, the drilling waste must be handled appropriately as per *Guide 50* and/or *Guide 58*. If drilling waste was disposed at an approved waste management facility, proof of this disposition (e.g. manifests, truck tickets, invoices, Alberta Oilfield Waste Form, etc.) must be listed as Reference Documents on the checklist. Reference documents must be submitted to Alberta Environment, if requested. If the well licensee does not have documentation verifying waste disposition, a Phase 2 ESA is required.

2. Hydrocarbon & Toxicity Management

Wastes from hydrocarbon-based fluids must be disposed of in accordance with *Guide 50* or taken to an EUB or AENV approved waste management facility. Drilling wastes taken to an approved waste management facility are subject to the tracking, characterization, and classification requirements under *Guide 58* and subsequent updates to it. On or off lease disposals by land treatment must have post-disposal sampling information and analytical data demonstrating compliance with the requirements of *Guide 50* and the land treatment approval. In addition, land treatment sites remote to the wellsite require reclamation certification. Alternative disposal methods must have information demonstrating compliance with the EUB approval.

Guide 50 requires testing of the waste for hydrocarbons if they are intentionally or inadvertently added to the drilling fluids. Under *Guide 50*, hydrocarbon concentration in the final soil waste mix must not exceed 0.1% (dry weight basis) for land treatment on subsoil, landspreading, and mix-bury cover or 0.5% (dry weight basis) for land treatment on topsoil. Alberta Environment will accept existing file information showing that these endpoints were met in the final soil-waste mix. Laboratories may provide the wet weight hydrocarbon values on the analytical back-up data results but the calculations on the *Notification of Drilling Waste Disposal* form require the dry weight value. Wet weight values can be converted to dry weight using the moisture content of the drilling waste sample.

If drilling waste was disposed at an EUB or AENV approved waste management facility, documentation verifying use of the facility (e.g., manifests, truck tickets, invoices, Alberta Oilfield Waste Management Form) must be listed as Reference Documents on the checklist. Reference documents must be submitted to Alberta Environment, if requested. If the well licensee does not have proof of the drilling waste disposition, a Phase 2 ESA is required.

Hydrocarbon systems, such as diesel inverts, contain high hydrocarbon concentrations. If waste from hydrocarbon-based systems was disposed of on-site, a Phase 2 ESA under Compliance Option Three is required. Other drilling fluids may contain lower hydrocarbons concentrations resulting from hydrocarbon additives or contamination from the formation. Risk of formation fluids entering the waste are greater for horizontal oil wells and underbalanced drilling techniques. The well license must indicate if a well was classified as a horizontal oil well or whether underbalanced drilling was used. Returned drill stem test fluids, a flow, or a kick may introduce produced fluids (hydrocarbons or salts) into the drilling fluids. If any of these actions have occurred, documentation must be available to demonstrate that the produced fluids were segregated from the drilling system (i.e., tanked or returned to tank trucks) and managed in accordance with *Guide 50* or *Guide 58*.

A number of drilling fluid additives are used to ensure the fluid properties are compatible with the geological conditions encountered during drilling. Additives that may have toxicity concerns include bactericides, corrosion inhibitors, defoamers, emulsifiers and de-emulsifiers, foaming agents, lubricants, polymer stabilizers and breakers, surfactants, and shale control inhibitors. Information on the toxicity of additives is available from the Petroleum Services Association of Canada (http://www.psac.ca/). The additives used in the drilling process must be identified and described (e.g., chrome-free lignosulfonate, aldehyde-based bactericide, etc.) so that potential toxicity and trace metal exceedances can be evaluated.

3. Metals (Trace Elements) Management

Drilling fluid additives may contain trace metals and depending on the quantities used, the drilling waste disposal area may exceed the *Canadian Environmental Quality Guidelines* for agricultural land use (CCME 1999 as updated). Metal sources of concern include, but are not limited to, the following:

- Zinc carbonate ($ZnCO_3$) is commonly used to remove H_2S if it is encountered during drilling. In some cases, $ZnCO_3$ is contaminated with cadmium. If the the checklist indicates that a Phase 2 ESA sampling program is required to assess zinc concentrations, cadmium must also be measured.

- Barite ($BaSO_4$) is used to increase fluid density.

- Chrome lignosulphonates were commonly used as thinners at one time, but have been largely phased out.

Calculation Tables are provided for the most common metal additives. If any of these additives were used, the Calculation Table for the appropriate metal must be used to evaluate the need for a Phase 2 ESA. If other trace metals specified in *Guide 50* were added to the drilling fluid in excess of the *Guide 50* analysis thresholds, analytical data and the application rate (land treatment, landspreading, landspraying and landspray-while-drilling) or the maximum applied quantity (mix-bury-cover) must be available. If the information is not available or the application rate or maximum applied quantity exceed *Guide 50* requirements, a Phase 2 ESA must be conducted.

4. Salinity Management

Salts or salt generating additives can be classified as sodium salts, calcium salts, potassium salts and nitrogen salts. Within each classification, there are several individual compounds, as listed in Appendix A. The Salt Calculation Table must be used to evaluate the potential salinity of the waste. If the drilling waste does not meet the targets specified in the Salt Calculation Table, a Phase 2 ESA is required.

Salt zones can be encountered during drilling and contaminate drilling waste. The daily drilling reports, Tour Reports and/or other drilling records will indicate if a salt zone was encountered during drilling. If drilling occurred in a salt zone, or returned drill stem test fluids, a flow, or a kick occurred, documentation must be available to demonstrate that the resulting drilling waste was appropriately treated or disposed as according to *Guide 50* or *Guide 58*. If the well licensee cannot provide this information, a Phase 2 ESA is required.

Compliance Option 2 - Drilling Waste Disposal Assessment Checklist

If any response to the checklist questions leads to a Phase 2 ESA requirement, one must be conducted in accordance with Compliance Option Three. If the information required in the Compliance Option Two Checklist is not available, a Phase 2 ESA must be completed.

1. General Disposal and Drilling Fluid Information:
The well licensee should be able to review various sources of information pertaining to the drilling activities on-site. Many information sources, other than the *Notification of Drilling Waste Disposal* form from *Guide 50*, can be reviewed for information relating to the drilling waste disposal and drilling fluid systems. These can include Tour Reports, daily drilling records, well files, and contractor invoices.

1.0 Well Information: Unique Identifier (UI) _____
Spud Date _____
Well Depth _____

1.1 Disposal Method (if known)*: _____
* If waste was disposed at an EUB or AENV approved facility, list supporting documentation under Reference Documents.

1.2 Disposal Location (if known)** _____
** If checklist indicates that a Phase 2 ESA is required, it must be undertaken at the disposal location. If the disposal location is unknown, the Phase 2 ESA must be undertaken at the wellsite.

	Yes	No
1.3 Has the well licensee reviewed the Daily Drilling Records and other available drilling documentation?	☐	☐ Phase 2 required
1.4 Can it be determined from the available records what type of drilling fluid system was used?	☐	☐ Phase 2 required
1.5 Were water-based drilling fluids used for all sections (i.e., gel chemical drilling fluid systems)?	☐	☐
If No, is there evidence that demonstrates the non water-based wastes were disposed of in a manner consistent with *Guide 50* or *Guide 58* (i.e., appropriately approved waste management facility)?	☐	☐ Phase 2 required
1.6 Is a mud list available?	☐	☐ Phase 2 required
If Yes, can all the additives on the mud list be identified and described? Record the additives and their description (e.g., chrome-free lignosulfonate, aldehyde-based bactericide) on the attached form.	☐	☐ Phase 2 required

2. Hydrocarbon Management

	Yes	No
2.1 Was the well a horizontal oil well?	☐	☐
If Yes, is there evidence that wastes were disposed of in a manner consistent with *Guide 50* or *Guide 58* (i.e., approved waste management facility)?	☐	☐ Phase 2 required
2.2 Was the well drilled using under-balanced techniques?	☐	☐
If Yes, is there information/documentation available to demonstrate that the drilling wastes were disposed of in a manner consistent with *Guide 50* or *Guide 58* (i.e., approved waste management facility)?	☐	☐ Phase 2 required
2.3 Do the Daily Drilling Records show evidence of returned drill stem test fluids, evidence of a flow, or evidence of a kick that may have resulted in the introduction of produced fluids (i.e., hydrocarbons or salts) into the drilling fluids?	☐	☐
If Yes, is there information/documentation available to demonstrate that they were appropriately treated or disposed of as per *Guide 50* or *Guide 58* (i.e., approved waste management facility)?	☐	☐ Phase 2 required
2.4 Was hydrocarbon added to the drilling fluid?	☐	☐
If Yes, was the hydrocarbon contaminated drilling waste disposed of in a manner consistent with *Guide 50* or *Guide 58* (i.e., approved waste management facility)?	☐	☐ Phase 2 required

3. Metals (Trace Elements) Management

	Yes	No
3.1 Was barite added to the drilling fluid?	☐	☐
If Yes, did it meet the requirements specified in the attached metal calculation table?	☐ Show calculation on attached form	☐ Phase 2 required
3.2 Was zinc carbonate added to the drilling fluid?	☐	☐
If Yes, did it meet the requirements specified in the attached metal calculation table?	☐ Show calculation on attached form	☐ Phase 2 required
3.3 Were chrome-based thinners added to the drilling fluid?	☐	☐
If Yes, did it meet the requirements specified in the attached metal calculation table?	☐ Show calculation on attached form	☐ Phase 2 required
3.4 Were any other additives used that would have triggered testing for metals under *Guide 50*?	☐	☐
If Yes, are waste analytical data and application rates (land treatment, landspreading, landspraying, landspray-while drilling) or maximum application (mix-bury-cover) available?	☐	☐ Phase 2 required
If above data is available, did the application rate or maximum application meet *Guide 50* requirements?	☐	☐ Phase 2 required

4. Salinity Management

	Yes	No
4.1 Does the water based drilling waste meet the requirements specified in the attached Salt Calculation Table?	☐ Show calculation on attached form	☐ Phase 2 required
4.2 Was a salt zone encountered during drilling?	☐	☐
If Yes, is there evidence that demonstrates the drilling wastes were disposed of in a manner consistent with *Guide 50* or *Guide 58* (i.e., appropriately approved waste management facility)?	☐	☐ Phase 2 required

Mud Additives (Attach additional pages if necessary.)

Product Name	Amount Used (units)	Brief Description of Product

Reference Documents (List all source documents used in the completion of this checklist. Attach additional pages if necessary. Documents must be supplied to Alberta Environment, if requested.)

Comments (Please provide any additional comments relevant to the decision process within the checklist. Attach additional pages if necessary.)

D. COMPLIANCE OPTION THREE

1. Phase 2 Environmental Site Assessments

Soil samples must be taken from within the drilling waste disposal area. The samples must be analyzed for all parameters of concern as identified by drilling fluid additive records. Information on drilling fluid additives can be obtained from Tour Reports, daily drilling records and company files. Where drilling records are not available, incomplete, or the composition of the additives is unknown, the samples must be analyzed for petroleum hydrocarbons, the trace elements specified in *Guide 50* plus barium, electrical conductivity (EC) and sodium adsorption ratio (SAR). The sampling densities specified below are minimum requirements. Where conditions indicate unusually high variability or disposal of high risk drilling fluids (e.g., diesel invert, high salinity fluids), assessors should increase sampling effort accordingly.

If the Phase 2 ESA analytical data indicates that the drilling waste disposal area does not meet the guidelines described below, the drilling waste disposal area must be managed to achieve equivalent land capability in order to receive a Reclamation Certificate. Confirmatory sampling requirements in support of site closure will be site-specific and must be conducted by a qualified person.

(a) Sampling Requirements

The minimum sampling requirements below are for drilling waste disposal areas only. They must be used to characterize the disposal area after its location has been identified. The level of effort required to find the waste disposal area, as well as environmental site assessment requirements for other areas of the site (e.g. well centre, flare pits, spills, etc.), will be site-specific. The sampling requirements below are for characterizing known waste disposal areas.

<u>On-Site Land Treated, Buried and/or Landspread Waste from up to 3 Single Wells</u>
Note: These requirements also apply to areas of the lease receiving liquid waste during squeezing or dump and bail operations.

The minimum number of sampling locations from the disposal area will vary with well depth as follows:

Well Depth* (m)	Number of Sampling Locations
<1500	3
1500 to 2500	4
>2500	5

*If two or three wells have been combined, the sum of the individual well depths must be used.

Sampling locations must be arranged so that the entire drilling waste disposal area is represented. For each sampling location, a sample must be submitted for laboratory analysis that is representative of the waste or soil-waste mix zone. Waste or soil-waste mix samples must not contain cover or base material. Samples must not combine material from more than one of the depth increments specified for the *Guide 50 Equivalent Salinity Guidelines* (below). For example, if the mix-bury-cover disposal area has only 0.9 m of cover, the top 0.10 m of the drilling waste disposal zone must be sampled separately.

Samples from different sampling locations or boreholes must not be combined. Borehole logs must show that the borehole extended to at least 1 meter below the base of the waste zone and must characterize the entire borehole depth. Site assessment must indicate if permeable material is present within 1 meter of the base of the soil-waste mix. Permeable material is

defined as having a median grain size greater than 75 microns. One or more control samples are required for comparison of background salinity levels unless the disposal area meets the *G50 Equivalent Salinity Guidelines* (below). Control samples may also be useful for evaluating naturally elevated metal concentrations and other anomalies. Control samples must be taken from an undisturbed profile in similar landscape positions and at the same depths as the waste material. Soil at the control locations must be representative of the soil found on the site and must not be contaminated. The information submitted to Alberta Environment must include the analytical results, sampling locations and depth, and drill logs/soil profile descriptions that show material changes with depth.

Land Treatment, Remote Multi-well Disposal Area, or On-site Disposal from More than 3 Single Wells

These areas must be delineated (e.g., visual identification of drilling waste, EM surveys, etc.) and a site-specific sampling and analytical program developed that is based on disposal area or volume.

Analysis of Samples

Samples must be analyzed for the parameters of concern identified by the Compliance Option One or Two Checklist. Electrical conductivity (EC), sodium adsorption ratio (SAR), trace elements, and petroleum hydrocarbons must be measured if available information was not sufficient to complete the Checklists. EC and SAR must be measured in a saturated paste extract. Trace elements must be measured after extraction by strong acid digest. Analysis of petroleum hydrocarbons conducted after January 1, 2002 must comply with the *Reference Method for the Canada Wide Standard for Petroleum Hydrocarbons in Soil - Tier I Method.*

Analytical results must meet the guidelines specified below.

Salinity Guidelines

Guide 50 Equivalent Salinity Guidelines in the following table may be used as an alternative to the *Salt Contamination Assessment and Remediation Guidelines* (Alberta Environment 2001).

Guide 50 Equivalent Salinity Guidelines

Topsoil	EC of 2 dS/m, SAR of 6
Below topsoil to 1 metre	EC of 3 dS/m, SAR of 8
Below 1 metre	EC of 6 dS/m, SAR of 10

Guide 50 Equivalent Salinity Guidelines for topsoil must not be exceeded. Below topsoil, if receiving soil exceeds these guidelines because of naturally occurring salt, an increase of 1 dS/m for EC and 1 unit for SAR above pre-disposal receiving soil background will be accepted. Alternatively, compliance with Alberta Environment's *Salt Contamination Assessment and Remediation Guidelines* (2001) is accepted.

Use of the *Guide 50 Equivalent Salinity Guidelines* assumes compliance with other *Guide 50* requirements. In particular, for the mix-bury-cover disposal method, the base of the soil-waste mix must be at least 1 meter above a layer of permeable material. Permeable material is defined as having a median grain size greater than 75 microns. Every effort should be made to ensure that a minimum of 1 meter of clean subsoil is maintained over the soil-waste mix before topsoil is replaced.

The purpose of using clean subsoil is to ensure that the root zone remains free of contamination. EC and SAR levels of the subsoil used for capping must meet the above

guidelines. In many soils this means that some or all of the subsoil excavated during sump construction is not suitable capping material. Sites that do not meet the above guidelines because naturally saline soils have been mixed into the capping material must be managed to meet equivalent land capability in order to be eligible for a Reclamation Certificate.

Hydrocarbon Guidelines

Petroleum hydrocarbon concentrations must comply with the *Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities* (Alberta Environment 2001).

File information confirming that mineral oil and grease concentrations in the soil-waste mix were 0.1% (dry weight) or less in subsoil or 0.5% (dry weight) in topsoil will be accepted in lieu of current site assessment data for hydrocarbons.

Trace Element Guidelines

Concentrations of trace elements including cadmium, chromium, copper, lead, nickel, vanadium and zinc must comply with the *Canadian Environmental Quality Guidelines* (CCME 1999 as updated) for agricultural land use.

Barium concentrations must comply with the guideline for Total Barium at Barite Sites from the *Alberta Soil Quality Guidelines for Barite: Environmental Health and Human Health* (AENV 2004).

For boron and other substances that are

a) not listed in the *Canadian Environmental Quality Guidelines* (CCME 1999 as updated); or
b) are referenced as interim remediation criterion in the *Canadian Environmental Quality Guidelines*,

refer to the *Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation* (Alberta Environment 1994).

Metal Calculations for Compliance Options One and Two

Note: Different target values are provided for well depth-based calculation alternatives depending on whether the well was drilled before or after October 22, 1996. The current *Guide 50, Drilling Waste Management*, which was issued by the Energy and Utilities Board on this date, increased the minimum mix ratio requirement from 1:1 to 3:1.

Barite:

Directions: Fill in the number of sacks and adjust for sack weight if different than 40 kg. Enter the Well Depth and divide the Total Number of Sacks by the Well Depth. Enter the result as Sacks per Metre. This value must be less than or equal to **0.07** for wells drilled before October 22 1996, or **0.2** for wells drilled on or after October 22, 1996. If the value exceeds the objective, a Phase 2 ESA must be conducted.

Total Number of Sacks (40 kg/sack*)		Well Depth (m)		Sacks per Metre
	+		=	

* Sack weight may be adjusted by dividing the number of sacks by 40 and multiplying by the actual sack weight in kilograms. This value should be entered as the number of sacks.

Zinc Carbonate:

Alternative 1:

If waste zinc, mix ratio and waste dry bulk density data are available use the following calculator to estimate post-disposal zinc concentration.

Directions: Enter the total zinc concentration measured in the waste, the Waste Dry Bulk Density, and Mix Ratio in the appropriate cells. Multiply Waste Zinc Concentration by Waste Dry Bulk Density and divide the result by the Mix Ratio. Divide this value by 1500 and add 70. The result is the Post-Disposal Zinc Concentration. This value must be less than or equal to **200** mg/kg. If the value exceeds this objective, a Phase 2 ESA must be conducted.

Waste Zinc Concentration (mg/kg)		Waste Dry Bulk Density* (kg/m^3)		Mix Ratio**						Post-Disposal Zn Concentration (mg/kg)
	x		+		+	1500	+	70	=	

* Waste Dry Bulk Density = (Waste Specific Gravity - 1) x 1600

** Enter the number of parts of soil mixed with one part of waste. For example, for a 3:1 mix ratio (3 parts soil to 1 part waste) enter "3".

Alternative 2:

If the above data is not available use the following equation to calculate the number of sacks of zinc carbonate added per meter drilled.

Directions: Fill in the number of sacks and adjust for sack weight if different than 25 kg. Enter the Well Depth and divide the Total Number of Sacks by the Well Depth. Enter the result as Sacks per Metre. This value must be less than or equal to **0.0065** for wells drilled before October 22 1996, or **0.018** for wells drilled on or after this date. If the value exceeds the objective, a Phase 2 ESA must be conducted.

Total Number of Sacks (25 kg/sack*)		Well Depth (m)		Sacks per Metre
	+		=	

* Sack weight may be adjusted by dividing the number of sacks by 25 and multiplying by the actual sack weight in kilograms. This value should be entered as the number of sacks.

Chromium-based Thinner:

Alternative 1:

If waste chromium, mix ratio and waste bulk density data are available use the following calculator to estimate post-disposal chromium concentration.

Directions: Enter the total chromium concentration measured in the waste, the Waste Dry Bulk Density, and Mix Ratio in the appropriate cells. Multiply Waste Chromium Concentration by Waste Dry Bulk Density and divide the result by the Mix Ratio. Divide this value by 1500 and add 30. The result is the Post-Disposal Chromium Concentration. If this value is greater than **64 mg/kg**, a Phase 2 ESA is required.

Waste Chromium Concentration (mg/kg)		Waste Dry Bulk Density* (kg/m^3)		Mix Ratio						Post-Disposal Cr Concentration (mg/kg)
	x		÷		+	1500	+	30	=	

* Waste Dry Bulk Density = (Waste Specific Gravity - 1) x 1600

** Enter the number of parts of soil mixed with one part of waste. For example, for a 3:1 mix ratio (3 parts soil to 1 part waste) enter "3".

Alternative 2:

If the above data is not available use the following equation to calculate the number of sacks of chrome thinner added per meter drilled. If the number of sacks exceeds the limits below, a Phase 2 is required.

Directions: Fill in the number of sacks and adjust for sack weight if different than 25 kg. Enter the Well Depth and divide the Total Number of Sacks by the Well Depth. Enter the result as Sacks per Metre. This value must be less than or equal to **0.02** for wells drilled before October 22 1996, or **0.05** for wells drilled on or after this date. If the value exceeds the objective, a Phase 2 ESA must be conducted.

Total Number of Sacks (25 kg/sack*)		Well Depth (m)		Sacks per Metre
	÷		=	

* Sack weight may be adjusted by dividing the number of sacks by 25 and multiplying by the actual sack weight in kilograms. This value should be entered as the number of sacks.

Salt Calculations for Option 2:

Alternative 1

If the volume of drilling waste is known, use the following calculator to determine the NaOH Equivalent Sacks per m^3 of waste. If this value is greater than **0.1**, a Phase 2 ESA is required.

Directions: Fill in the number of sacks and adjust for sack weight if different than 25 kg. For each additive, multiply the Number of Sacks by the NaOH Equivalency Factor and write the result in the NaOH Equivalent Sacks column. Sum all the entries in the NaOH Equivalent Sacks column and enter the result. Enter the Waste Volume and divide the Total NaOH Equivalent Sacks by the Waste Volume. Enter the result as Equivalent Sacks per m^3. This value must be less than **0.1**.

Additive	Number of Sacks (25 kg/sack*)		NaOH Equivalency Factor		NaOH Equivalent Sacks
Caustic Soda		X	1.00	=	
Soda Ash		X	0.75	=	
Sodium Chloride		X	0.68	=	
Sodium Bicarbonate		X	0.95	=	
Sodium Silicate		X	1.37	=	
Sodium acid pyrophosphate (SAPP)		X	0.22	=	
Calcium Chloride		X	0.72	=	
Calcium Nitrate		X	0.34	=	
Envirofloc		X	0.41	=	
Gypsum**		X	0.59	=	
Lime**		X	1.08	=	
** Max = 0.02 x well depth (m)					
Potassium chloride		X	0.54	=	
Potassium sulphate		X	0.46	=	
Caustic potash		X	0.71	=	
Potassium formate		X	0.47	=	
Potassium silicate		X	0.32	=	
Potassium nitrate		X	0.40	=	
Diammonium phosphate		X	0.63	=	
Ammonium nitrate		X	0.57	=	
Ammonium sulphate		X	0.61	=	
			Total NaOH Equivalent Sacks	=	
			Waste Volume (m^3)	÷	
			Equivalent Sacks per m^3	=	

* Sack weight may be adjusted by dividing the number of sacks by 25 and multiplying by the actual sack weight in kilograms. This value should be entered as the number of sacks.

**Note: Up to 0.02 sacks of gypsum and lime per metre of well depth should be counted with other salt additives. Because of the limited solubility of gypsum and lime, sacks in excess of this value need not be counted.

Alternative 2

If the volume of drilling waste is not known, use the following calculator to determine the NaOH Equivalent Sacks per metre of well depth. This value must be less than **0.026** for wells drilled before October 22 1996, or **0.035** for wells drilled on or after this date. If the value exceeds the target, a Phase 2 ESA must be conducted.

Directions: Fill in the number of sacks and adjust for sack weight if different than 25 kg. For each additive, multiply the Number of Sacks by the NaOH Equivalency Factor and write the result in the NaOH Equivalent Sacks column. Sum all the entries in the NaOH Equivalent Sacks column and enter the result. Enter the Well Depth and divide the Total NaOH Equivalent Sacks by the Well Depth. Enter the result as Equivalent Sacks per Metre.

Additive	Number of sacks (25 kg/sack*)		NaOH Equivalency Factor	NaOH Equivalent Sacks
Caustic Soda		X	1.00	=
Soda Ash		X	0.75	=
Sodium Chloride		X	0.68	=
Sodium Bicarbonate		X	0.95	=
Sodium Silicate		X	1.37	=
Sodium acid pyrophosphate (SAPP)		X	0.22	=
Calcium Chloride		X	0.72	=
Calcium Nitrate		X	0.34	=
Envirofloc		X	0.41	=
Gypsum**		X	0.59	=
Lime**		X	1.08	=
** Max = 0.02 x well depth (m)				
Potassium chloride		X	0.54	=
Potassium sulphate		X	0.46	=
Caustic potash		X	0.71	=
Potassium formate		X	0.47	=
Potassium silicate		X	0.32	=
Potassium nitrate		X	0.40	=
Diammonium phosphate		X	0.63	=
Ammonium nitrate		X	0.57	=
Ammonium sulphate		X	0.61	=
			Total NaOH Equivalent Sacks	=
			Well Depth (m)	÷
			Equivalent Sacks per Metre	=

* Sack weight may be adjusted by dividing the number of sacks by 25 and multiplying by the actual sack weight in kilograms. This value should be entered as the number of sacks.

**Note: Up to 0.02 sacks of gypsum and lime per metre of well depth should be counted with other salt additives. Because of the limited solubility of gypsum and lime, sacks in excess of this value need not be counted.